SFB 649 Discussion Paper 2011-066

Monitoring, Information Technology and the Labor Share

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This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

SFB 649 ECONOMIC RISK BERLIN

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October 17, 2011

This paper assesses empirically the hypotheses by Bental and Demougin (2010) that innovations in ICT (Information and Communication Technology) reduce the labor share in OECD countries by improving the monitoring technology. In a first step, I show that data trends for the labor share, wages in efficiency units, and labor in efficiency units over capital can be matched by a simulation of the model of Bental and Demougin (2010). In a second approach, I confirm increasing monitoring of workers using micro data for Germany. I argue that ICT influences labor not only through substitutability of labor with ICT and foreign work, but also through to lowering rents of workers as monitoring technology improves.

Keywords: Labor Shares, Bargaining, Monitoring
JEL Classification:D24, J30, E25

*I would like to thank Benjamin Bental, Michael Burda, Dominique Demougin, Jenny Kragl and Anja Schöttner as well as participants at the Annual Congress of the European Association of Labour Economists 2007 and the European School on New Institutional Economics 2007 for helpful comments and discussions. Financial support by the Deutsche Forschungsgemeinschaft through the CRC 649 "Economic Risk" is gratefully acknowledged. All remaining errors are mine. *Address:* Humboldt-Universität zu Berlin, School of Business and Economics, Institute for Economic Theory II, Spandauer Str. 1, 10099 Berlin, *e-mail:* schnedor@staff.hu-berlin.de

1 Introduction

Since the 1980s the income share of labor has decreased in many OECD countries. A common hypothesis for this decrease is capital augmenting technical change. Technological change, especially due to innovations in information and communication technology (ICT), is often assumed to be labor saving at least for specific skill groups. The labor saving aspect originates from a substitutability of ICT with labor. Bental and Demougin (2010) propose another channel through which ICT affects the labor share. In their model, ICT innovations enable more efficient monitoring of workers. With higher monitoring precision, the workers' rents can be reduced at every level of effort, which consequently lowers the labor share. The aim of this paper is to assess the model and the resulting hypotheses of Bental and Demougin (2010) against real world data.

Bental and Demougin (2010) explain the decreasing labor share by an institutional model where the downward movements the labor share, wages relative to productivity and effective labor relative to capital, are caused by an improvement in monitoring technology. The model is a partial equilibrium where a representative worker and a firm bargain over wage contracts. Since the worker's effort is not contractible, the firm offers him an incentive contract. The worker exerts more effort if he has a higher bargaining power and therefore receives a higher share of the profits. If the worker can be monitored, the need for incentives to induce effort is reduced. Consequently, as monitoring tightens, a given effort level can be achieved by lower bargaining power. Before bargaining takes place the firm has to invest into capital, which is the other input into production. As capital investments are made before wage bargaining, the firm faces a problem of irreversible investment. With a higher bargaining power for the firm, investment decisions are more efficient. If the bargaining power of the worker is reduced due to increased monitoring, the investment problem becomes less severe as the firm receives a higher share of the quasi-rents.

Bental and Demougin (2010) argue that the monitoring technology has steadily improved since 1980. It therefore takes less and less bargaining power to induce effort. The lower bargaining power relaxes the hold-up problem and investment into capital becomes more profitable. As a result, the labor share as well as wages decrease relative to productivity. As capital investments are more efficient, more capital is used in production relative to effective labor.

The falling labor share phenomenon is well known and has encouraged much research. Bentolia and Saint-Paul (2003), the European Commission (2007), and Checchi and Garcia-Penalosa (2010) find changes in labor market institutions, such as bargaining coordination, minimum wages, or unemployment benefits, to be influencing the labor share. Another set of studies focuses on the impact of globalization on the labor share. Harrison (2002), Guscina (2007), Jaumotte and Tytell (2008), and Jayadev (2007) show for different indicators for economic openness, that higher economic integration lowers the labor share in developed countries. Arpaia et al. (2009) argue that capital-augementing technological progress which is low-skilled labor saving, is a main force in reducing the labor share in Europe. The European Commission (2007) confirms a substitutability of low-skilled labor and capital, but find an overall positive correlation between labor and capital, similar to Checchi and Garcia-Penalosa (2010). The European Commission (2007) include ICT use in their analysis. Low-skilled work seems also substitutable to ICT, while the overall impact on the is insignificant. Schneider (2011) combines the analyses of economic integration and ICT innovations on the labor share. The study shows that there is a combined impact of ICT innovations and economic integration on the labor share.

Similar to the studies described above, the model by Bental and Demougin (2010) includes changes in labor market institutions and ICT innovations as causes for the decrease in the labor share. The causal relationship is nevertheless different. While bargaining power is exogenous in other studies, it is endogenous in the model by Bental and Demougin (2010) and reacts to improvements in monitoring technology. Furthermore, ICT does not decrease wages, because the price of labor has to fall as its substitute, ICT, becomes cheaper, but because ICT reduces the information rents of the workers due to improvements in monitoring technology. I assess the hypotheses of Bental and Demougin (2010) empirically in two approaches. First, I simulate the model on a macro level for various countries. Then I analyze evidence of increasing monitoring intensity of workers on the micro level.

For the simulation of the model, I make two adjustments to the framework of Bental and Demougin (2010) it order to get a better fit to the data. First, I allow for a non-constant user cost of capital. Second, I analyze a suboptimal adjustment of the bargaining power, as I find this improves the results even more. Calibrating the model and simulating data for 1980 to 2000 shows that the adjusted model may explain the trends in the data.

For some countries, especially for France, the trends are well represented by the adjusted model, but the real-world data overshoots the predictions generated by a calibrated version of the model. To better match the levels, I assume, as a second adjustment to the Bental and Demougin (2010) approach, that the bargaining power is not distributed optimally, given the level of monitoring available. Specifically, in the case of France, assuming a biased bargaining process favoring labor generates results that are closer to the level of the real data. This seems likely as in the 1980s there was a labor favoring government under Mitterrand. For the US, the same exercise implies that there is a slight bias in favor of firms. For most other countries the optimal bargaining power implied by the model generates results that are consistent with the real-world data with respect to the trends as well as the level of the time series.

For the analysis of monitoring technology on the micro level, I use the German Socio-Economic Panel (SOEP) which has asked the participants how strongly they feel monitored on a three point scale. This question was asked in five waves between 1985 and 2001 and therefore covering almost the same time frame as the makro evaluation. The panel structure of the SOEP allows to distinguish between person specific effects and overall changes in the sample. I find that the overall average perceived monitoring intensity has increased between 1985 and 2001, while individuals feel less monitored over time. The individual effect can be explained by career advancement which lead to less monitored positions. These results are further hints on the reduction of wages due to improvements in the monitoring technology.

In the remainder of this paper, I will first present the model of Bental and Demougin (2010) with its main results in section two. In section three, I explain the calibration and discuss the results of the simulation. Section four shows the empirical assessment on the micro level and section five concludes.

2 The Model

Bental and Demougin (2010) consider a partial-equilibrium model with a principal-agent framework. A representative worker is employed by a representative firm. Both firm and worker are risk-neutral. The firm produces output with capital and labor employing a Cobb-Douglas technology. Specifically, the production function is of the form

$$F(e,k) = e^{\nu} k^{\gamma}, \qquad \nu, \gamma \in [0,1] \tag{1}$$

where e is the level of effort and k the level of capital per worker.

The worker's effort is not contractible. Therefore, he is paid via a bonus contract, which depends on a contractible binary signal $s \in \{0,1\}$. The probability of observing a positive signal, $s = 1$, increases in the effort of the worker. The better the signal reflects effort, the lower is the probability of obtaining a bonus for any effort of the worker. The firm is able to monitor the agent. It is assumed that an advanced monitoring technology is characterized by its ability to measure effort with a signal more precisely. Thus, given the effort of a worker, his bonus can be reduced with a higher monitoring precision.

The timing of the model is as follows. First the firm hires capital, then the worker and the firm are matched and bargain over quasi-rents. Bargaining is modeled as a generalized Nash Bargaining process, with bargaining power being determined by some institutional rules. Next, the worker chooses a level of effort, production takes place, and the signal is observed. Finally, wages are paid.

The problem is solved by backward induction. At the last stage, the worker decides upon his effort, given the bonus and the level of monitoring. The bonus is determined by the Nash-Bargaining Solution, assuming that the firms and workers have an outside option of zero. As the firm hires capital before bargaining, by the time of bargaining, the costs of capital are sunk. Thus, the firm faces a hold-up situation. Anticipating this, the firm's incentives to invest in capital are small, if the bargaining power of the workers is high, since the firm's share of the profit is small. On the other hand, under equal circumstances, higher incentives for the worker lead to higher effort. An optimally chosen bargaining power maximizes net output as a trade off between effort and capital inputs.

Bental and Demougin (2010) show that the labor share (LS), defined as expected bonus payments divided by total output, is

$$LS = (1-\alpha)\,\nu + \alpha, \qquad \alpha \in [0,1] \tag{2}$$

where α is the worker's bargaining power. As ν is bounded between zero and one, the labor share increases if α increases.

The capital-output ratio is

$$\frac{k}{y} = \frac{\gamma\,(1-\alpha)}{r}, \tag{3}$$

where r is the user cost of capital. It is equal to the interest rate, which Bental and Demougin (2010) assume to be constant, as the relative price of capital is normalized to unity.

In order to compare the model's results with real-world data Bental and Demougin (2010) translate the production function into a production function with a Harrod-neutral productivity factor. The resulting efficiency units, (E), can be written in terms of effort

$$E = e^{\frac{\nu}{1-\gamma}}. \tag{4}$$

Thus, the wage per efficiency unit, (W/E), is

$$\frac{W}{E} = \left[(1-\alpha)\,\nu + \alpha\right]\left(\frac{\gamma\,(1-\alpha)}{r}\right)^{\frac{\gamma}{1-\gamma}}. \tag{5}$$

Given equations 2 and 3, this can be written as,

$$\frac{W}{E} = LS\left(\frac{k}{y}\right)^{\frac{\gamma}{1-\gamma}}. \tag{6}$$

The last variable to be considered here is the ratio of labor in efficiency units to capital.

$$\frac{E}{k} = \left(\frac{\gamma\,(1-\alpha)}{r}\right)^{-\frac{1}{1-\gamma}} = \left(\frac{y}{k}\right)^{\frac{1}{1-\gamma}}. \tag{7}$$

Bental and Demougin (2010) assume that the bargaining power is set by a social planner who maximizes the sum of the worker's rent and the firm's profit. Consequently, the worker's bargaining power is a function of the monitoring technology. If the monitoring precision increases, the worker's bargaining power decreases and so does the labor share. Additionally, the capital-to-output ratio increases. Both capital and output increase due to a change in the monitoring technology. Holding γ and r constant, it is clear that capital increases faster than output since the bargaining power of the firm increases. Thus, an improved monitoring precision followed by a shift in bargaining power in favor of the firm, causes a decrease in real wages relative to efficiency units. Further, as capital increases faster than output, the labor in efficiency units per capital decreases.

In the following sections I first describe the observable data and then compare the real world-data to the simulated data.

3 Macroeconomic Assessment

3.1 Data Description

The data is taken from the OECD Economic Outlook and ranges from 1980 to 2000.[1] Labor shares were computed as total employment in the business sector times compensation per worker in the business sector divided by the nominal GDP of the business sector. It is therefore includes self-employed workers.

I calculate productivity following the standard assumption of a Cobb-Douglas production function with capital and effective labor.

$$Y_t = K_t^{\gamma} \left(A_t L_t\right)^{1-\gamma} \tag{8}$$

This leads to the following definition of efficiency units (productivity)

$$A_t = \left(\frac{Y_t}{K_t^{\gamma} L_t^{1-\gamma}}\right)^{\frac{1}{1-\gamma}}, \tag{9}$$

where A_t are the efficiency units in period t. Assuming now that the production technology is constant, γ is set to 0.3.

The time series of the OECD data are shown in figure 1. The top panel shows the labor shares, the middle panel shows the wages in efficiency units, and the bottom panel shows the amount of labor in efficiency units over capital.

The OECD-data, demonstrate that the labor share for France, Germany, the United States and the other countries of consideration has decreased over the last two and a half decades. In these countries, except for Japan and Spain, real wages relative to productivity have been decreasing as well in the same period, as can be seen in the second panel of figure 1. The neoclassical theory would now predict that as wages decrease, effective labor should increase relative to capital, as it becomes relatively cheaper. This is what has happened in the US and in Norway. There labor measured in efficiency units relative to capital has increased since 1980. This is shown in the third panels of figure 1. Analogously, effective labor relative to capital should decrease if wages relative to productivity increase. This is observable for Japan and Spain.

In France, Australia, Belgium, Italy, and Germany, the wages relative to productivity as well as the input of labor relative to capital decreased during the last two and a half decades. As mentioned above, this cannot be explained by the neoclassical approach. However it is consistent with the model by Bental and Demougin (2010). I show in the following section that with an extension of this model, not only the trends in France or Germany can be explained, but also the trends of the US, as well as Norwegian, Japanese or Spanish data.

[1] I am grateful for being able to use the OECD data set from Bental and Demougin, who in turn received the data from Olivier Blanchard. See Blanchard (2006) and Bental and Demougin (2010).

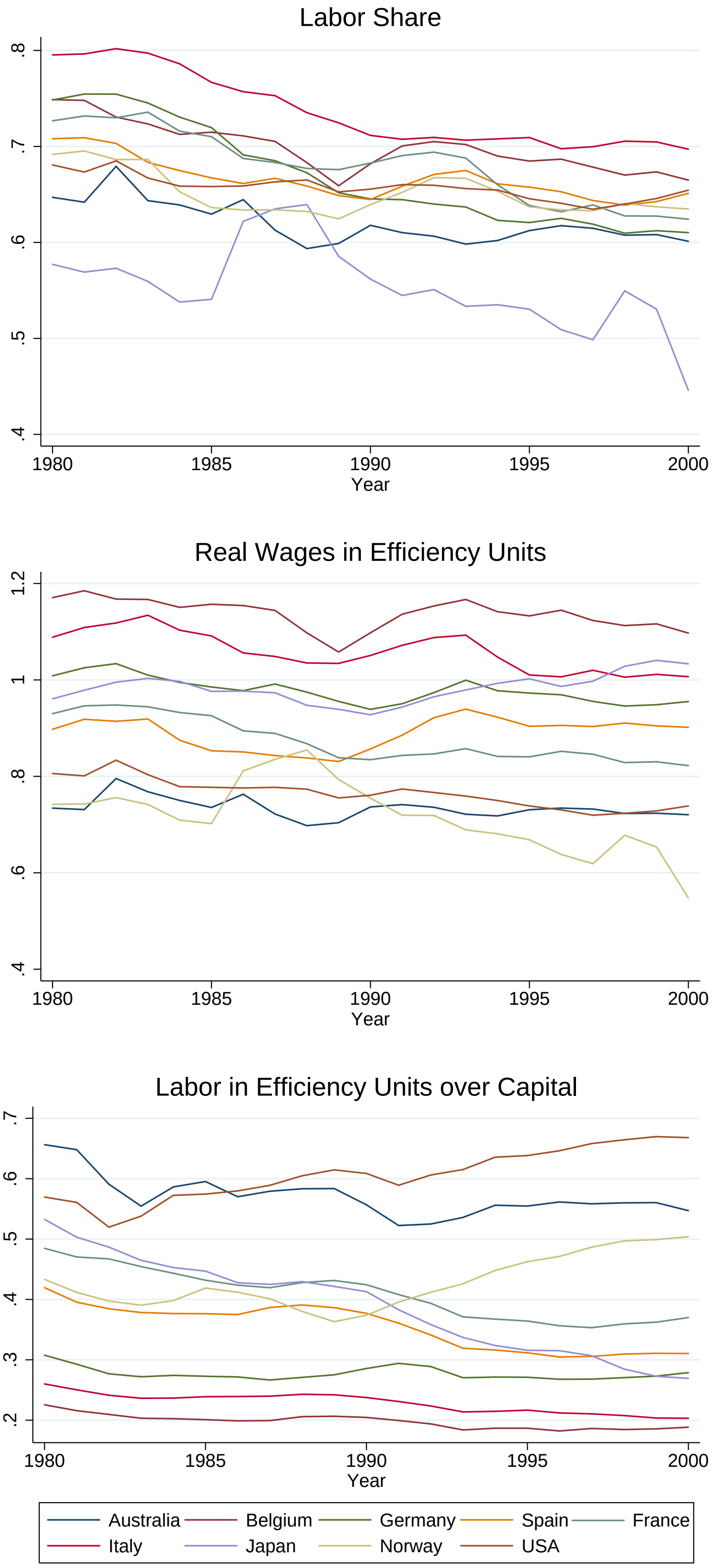

Figure 1: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital

3.2 Specifications of the Simulation

In order to show that the adjusted model can explain the trends I described before, I calibrate the model of Bental and Demougin (2010) and simulated the time frame from 1980 to 2000. In figures 2 to 10 the OECD-based data and the data from the simulated time series are presented within one figure, where the OECD data are represented by the black lines. These figures allow comparison of the real-world data to the simulated data with respect to trends and levels in order to decide whether the institutional approach leads to a suitable approximation.

In the simulation I calculate the optimal bargaining power, α, which is a function of the monitoring technology or precession, θ, the user cost of capital, r, the production function parameters, ν and γ and the cost of effort of the worker, c. Contrary to Bental and Demougin (2010), I assume that the user cost of capital is not constant over time. In order to determine the user cost from the model I use the labor shares equation (2) to compute a preliminary α[2]. Choosing an appropriate ν and using the OECD data, I compute for each year the resulting bargaining power of the worker.[3] Taking equation (3), the capital output ratio, it is then possible to find the user cost as $\frac{K_t}{Y_t}$ is also known from OECD-data. I compute the user cost of capital from

$$r_t = \gamma \left(1 - \alpha_t\right) \frac{Y_t}{K_t}. \tag{10}$$

With this approximate r_t, which varies across countries and the assumption of an increasing monitoring precision, I calculate the worker's optimal bargaining power. The bargaining power maximizes a social welfare function which equals the sum of the worker's and the firm's rent. The parameters and their values are given in table 1 and 2.

The user costs are determined by the movement of the labor share of the OECD data. The movement of the bargaining power depends also on the increasing monitoring precision. I calculated the optimal bargaining power for 20 periods, given the movement in the user costs between 1980 and 2000 and assuming an increase in the monitoring precision from 0.25 to 0.75 in these periods. With these parameters I simulate the labor share, equation (2), the wages per efficiency unit, equation (5), and the effective labor input relative to capital, equation (7). The resulting time series are shown as blue lines in figures 2 to 10.

3.3 Simulation Results

Optimal Bargaining Power

As it can be seen in figures 2 to 10, the trends of the time series can be reproduced with the simulation. Moreover the trends of data of the US, Norway, Japan and Spain, which do not follow the Neoclassical prediction, can be explained by this approach.

[2] There is a tension between the "empirical" α_t generated by equation (2), and the optimal one. Another approach is to simultaneously generate the optimal α_t and r_t, and then use the results to compute labor shares. The latter should be compared to the data. Unfortunately, this is computationally much more cumbersome within the simulation.

[3] I used a simple linear approximation of the labor shares between 1980 and 2000. This simplifies the calculation in the simulation program.

Parameter	Description	Values
α	worker's bargaining power	endogenous, $[0, 1]$
θ	monitoring precision	linearly increasing $[0.25, 0.75]$
ν	Cobb-Douglas parameter[4]	country specific, see table 2
γ	Cobb-Douglas parameter, capital	0.3
r	user costs of capital	country specific, see table 2
c	costs of effort	1.1

Table 1: Calibration of Parameters

Country	values for ν	resulting values for r_t
France	0.6	0.066 - 0.086
Australia	0.45	0.134 - 0.143
Belgium	0.5	0.055 - 0.06
Italy	0.5	0.061 - 0.074
Germany	0.5	0.077 - 0.087
USA	0.6	0.165 - 0.2
Norway	0.4	0.1 - 0.15
Japan	0.6	0.1 - 0.09
Spain	0.5	0.11 - 0.098

Table 2: Choice of ν and r_t for calibration

The graphs for Australia, Italy, Germany, Belgium, and France correspond to the predictions by Bental and Demougin (2010). As the moral-hazard problem weakens due to the increase in monitoring precision, the wages relative to productivity decrease. Since the hold-up problem slackens as well, firms invest more and productive labor relative to capital declines. At the same time the labor share decreases.

Interestingly, when assuming that the user cost of capital is not fixed over time, but adjusts in the model, the data of the US, Spain, Japan, and Norway are also explainable within the institutional setup. For the US data and the Norwegian data the wages relative to productivity decrease and effective labor relative to capital increases. For Japanese and Spanish data the model suggests, that the capital-output ratio increases faster than the labor share decreases. Therefore, wages relative to productivity increase and productive labor relative to capital decreases.

Biased Adjustment of Bargaining Power

Figure 2 shows a gap between the OECD and the simulated data if the bargaining power is adjusted optimally each period. Reasons for this gap can be found in the political process and the implementation of the institutions. The social planner does not necessarily give the same weight to the rents capital owners and workers when maximizing social welfare. Thus, I simulated the model for France assuming that the bargaining power of labor is biased towards labor. The dashed and dotted lines in figure 11 show cases where the bargaining power is determined by a welfare function that poses a higher valuation on the side of labor. I calculated the labor share, wages per efficiency unit, and the effective labor input relative to capital using the user cost of capital as in the optimal case, but with the following welfare function.

$$max_\alpha \, W = \pi \, (\text{worker's rent}) + (1 - \pi) \, (\text{firm's rent}) \tag{11}$$

π represents the weight of the interest group (workers and firms) in the social welfare function. The egalitarian rule, $\pi = 0.5$, is described in the subsection above. The higher π is, the more important is the workers welfare for the social planner or the more favorable are the bargaining institutions for the worker. These time series are shown as dashed/dotted lines in the figures for France, figure 11. For the US, figure 12, it is assumed that there is a bias towards the rent of the firm, implying that π may be smaller than 0.5.

The graphs show that as the adjustment process becomes more biased the simulated results get closer to the data. Specifically, the simulation results suggest that the French institutions induce a bargaining power of the workers which may be higher than expected given current state of technology and user cost of capital. Under the same assumption, the results for the US in figure 12 may indicate that institutions give slightly less bargaining power to the workers than under an optimal determination of bargaining power, since the actual labor share is below the simulated optimal labor share.

Similar results occur under the assumption of a sluggish adjustment process. In this case the regulator imposes a bargaining power which was optimal, given the monitoring technology

	N	Mean	Std. Dev.
Overall	18,748	1.66	0.722
by Occupational Position			
Apprentice	993	2.12	0.733
Self-Employed	1,509	1.21	0.511
Manual Laborer	7,514	1.84	0.750
Employee	7,399	1.51	0.644
Civil Servant	1,333	1.64	0.674
by Sector			
Manufacturing	3145	1.79	0.760
Service	5151	1.60	0.691
by Year			
1985	3,004	1.64	0.736
1987	3,306	1.65	0.737
1989	3,518	1.67	0.733
1995	4,567	1.65	0.707
2001	4,353	1.70	0.706

Table 3: Perceived Monitoring Intensity, Descriptive Statistics

and user cost of capital, five or ten periods before. Here the more lags are included the closer is the simulated data to the observed data. Both approaches lead to a much better fit in the levels of the simulation for both the France and the US.

4 Microeconomic Assessment

While it is not possible to simply estimate the parameter model of Bental and Demougin (2010), due to unobservable variables such as effort, some statistics from micro dataset can already indicate the relevance of the model. Specifically, I use data from the German Socio-Economic Panel Study (SOEP) to analyze monitoring at the workplace. The SOEP is an annual representative longitudinal micro-database with information on social and economic outcomes for private households in Germany since 1984. In the years 1985, 1987, 1989, 1995, and 2001 the SOEP asked the questions: *"Is your work strictly monitored?"*. The participant had three answers to choose from: *"Completely"* (3), *"Partly"* (2), *"Not At All"* (1). I use the information of this question as an indicator for the monitoring intensity at work, which is on a scale between one and three, where three is the highest level of monitoring intensity.

Table 3 shows some descriptive statistics for the sample. The sample contains only non-unemployed workers who are in the labor force. For the five years 18,748 observations are available and monitoring intensity has a mean of 1.66.

Splitting the sample into occupational positions shows that on average apprentices are monitored more closely than other occupational groups, while self-employed workers are least monitored. Monitoring is on average more intense in Manufacturing than in the service

Table 4: Changes of Monitoring Intensity over Time

	Dependent Variable: Monitoring Intensity						
	1	2	3	4	5	6	7
Trend	0.003***	0.007***	0.007***	0.007***	-0.004***	-0.003***	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age		-0.008***	-0.009***	-0.005***			
		(0.000)	(0.001)	(0.001)			
Education		-0.142***	-0.142***	-0.043***		-0.125***	-0.049*
		(0.007)	(0.007)	(0.008)		(0.026)	(0.026)
Tenure			0.001	0.000			0.003**
			(0.001)	(0.001)			(0.002)
Occ.Position 2				-0.773***			-0.648***
				(0.029)			(0.049)
Occ.Position 3				-0.184***			-0.292***
				(0.026)			(0.038)
Occ.Position 4				-0.504***			-0.397***
				(0.026)			(0.038)
Occ.Position 5				-0.336***			-0.143*
				(0.033)			(0.076)
Constant	1.639***	2.149***	2.156***	2.222***	1.697***	1.878***	2.055***
	(0.009)	(0.021)	(0.022)	(0.028)	(0.008)	(0.038)	(0.045)
Fixed Effects					✓	✓	✓
N	18748	18748	18595	18595	18748	18748	18595
R^2	0.001	0.038	0.038	0.104	0.002	0.004	0.025

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dummies for Occ.Position: (1) Apprentice, (2) Self-Employed, (3) Manual Laborer, (4) Employee, (5) Civil Servant.

sector. On an two digit level, industries with a relatively high monitoring intensity and at least 10 observations are "Manufacturing of Vehicles" with a mean intensity of 1.96 (N=311) or "Sewage" with a mean intensity of 1.91 (N=22). Low mean monitoring intensities can be found for the industries "Renting of Machinery", 1.2 (N=10), or "Research and Development", 1.31 (N=16). On average the monitoring intensity increases over time.

In the model by Bental and Demougin (2010), increasing monitoring intensity is the driving force of the changes in the labor share. In order to analyze if there has been indeed a significant increase in monitoring intensity over time, I regress a time trend and later further controls on the indicator for monitoring. The results can be found in table 4. The time trend mirrors the distance of the time periods where the monitoring question is asked, such that the variable *Trend=1, 3, 5, 11, 17.* Column one shows the results for a regression with only an intercept and the trend. The coefficient on trend indicates a significant increase of the monitoring intensity over time in the pooled sample. Correcting for age and education[5] shows an even stronger positive trend. Including tenure and correcting for the occupational position leaves the coefficient unchanged.

Columns 4 to 7 show the repeated estimations including person fixed effect. The coefficients are therefore estimated on the differences of the mean value of the variable by person. If the time trend is regressed on the monitoring intensity with person fixed effects, the coefficient

[5] Education is clustered by highest degree into three groups: high (tertiary education), medium (vocational or general maturity certificate), low (no degree to intermediate general qualification).

Table 5: Monitoring Intensity and Wages

	Dependent Variable: Real Gross Monthly Wage				
	1	2	3	4	5
Monitoring	-127.966***	-67.345***	-49.249***	-17.778**	-2.428
	(9.441)	(10.302)	(9.303)	(8.654)	(13.288)
Education			300.778***	169.725***	278.408***
			(35.031)	(34.491)	(73.457)
Tenure			32.809***	30.075***	29.521***
			(3.221)	(3.203)	(4.529)
Tenure sqrt			-0.853***	-0.653***	-0.754***
			(0.092)	(0.092)	(0.137)
Fixed Effects		✓	✓	✓	✓
Year Dummies			✓	✓	✓
Occ.Position				✓	✓
Industry					✓
Constant	✓	✓	✓	✓	✓
N	18748	18748	18595	18595	9282
r2	0.009	0.003	0.128	0.169	0.230

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

turns negative, indicating a decrease of the monitoring intensity over time. This is also indicated by the negative and significant coefficients on age and education. It can be expected that individuals are less intensely monitored if they are more experienced, have worked at the firm for a longer time, or are older and higher in the hierarchy. I therefore add controls for education, tenure, and occupational position. Adding all controls leaves the time trend insignificant and small.

The results from table 4 indicate that on average monitoring intensity increased for people with the same characteristics on age, education, and occupational positions. On an individual basis, monitoring intensity decreases throughout the working life, which can be explained by higher education and changes in job characteristics during the individual career.

A further central hypothesis of Bental and Demougin (2010) is that rents and wages are reduced when the monitoring precision is increases. Table 5 shows the correlations of the monitoring intensity and real gross monthly wages. I regress the monitoring intensity and a constant on the real gross monthly wages and later include further controls which are common in Mincer type wage regressions (Mincer, 1974). In pooled OLS regression higher wages can be associated with lower monitoring intensity. Including person fixed effects and therefore controlling for all individual effects that do not change over the observed time, reduces the coefficient but leaves it negative and significant. Including education and tenure as a measure for experience as well as year dummies to account for macroeconomic factors reduces the correlation again, but it remains significant. The same happens when dummies for the occupational position are included. Controlling for industry on a two-digit level reduces the sample size by half and the coefficient of the monitoring intensity is small and insignificant. The decreasing coefficient of monitoring intensity as controls are included may be explained by the collinearity of monitoring with occupational and industry characteristics. As the monitoring intensity will be higher in some occupations and industries than it others, the correlation of monitoring will most likely be taken up in the industry and occupation indicators.

Table 6: Changes in the Monitoring Intensity

Δ Monitoring	Frequency	Percent
-2	407	3.52
-1	2,075	17.97
0	6,716	58.16
1	1,995	17.28
2	355	3.07
Total	11,548	100.00

Descriptive statistics for changes in the monitoring intensity between two consecutive observation periods by person.

Furthermore, as mentioned above, the coefficients in the fixed effects regressions are identified only through changes from the individual mean. In order to see how many observations identify the coefficients on monitoring intensity, table 6 shows the amount of changes two subsequent periods in the monitoring variable. In 58 percent of cases the monitoring intensity reported by the subjects has not changed compared to the previous observation period. In about 36 percent of the cases the reported monitoring intensity moved by 1, in 6.5 percent by 2. In half of all changes a higher monitoring intensity than previously is reported and in the other half a lower. This also underlines the statement from above, that on an average individual level monitoring intensity did not increase over time, while the results from above show that the average monitoring intensity increased over time.

5 Conclusion

Bental and Demougin (2010) introduce a model which explains the downward trend of the labor share with an ICT induced improvement of monitoring precision which causes the rents of workers to fall. In this paper, I assess their hypotheses empirically. Their model is consistent with the downward trend of the labor share, wages relative to productivity, and effective labor relative to capital in France and other countries like Germany or Austria. I extend their model by allowing the user cost of capital to change over time. This leads to the conclusion that the model by Bental and Demougin (2010) is also consistent with the trends in macro economic US data as well as other countries like Norway, Spain, or Japan. Furthermore, analyzing German micro-panel data on the perceived monitoring intensity of workers, indicates that monitoring has indeed increased on average between 1985 and 2001.

The analysis of the impact of ICT on the labor share is closely connected to the analysis of the impact ICT on changes in the income distribution and on offshoring decisions. A recent strand of literature analyses how ICT influences the remuneration and relocation of specific tasks. Autor et al. (2003) introduce the idea that the production can be split into tasks which are routine and follow clear rules and tasks which non-routine. As the routine tasks can also be carried out by computers as clear rules are programmable, workers with routine tasks are substitutes to computers. The "Task"-literature explains decreasing wages and employment of workers with routine tasks, by the drop in prices of ICT. (Autor et al., 2003; Goos and Manning, 2007; Spitz-Oener, 2006; Acemoglu and Autor, 2011) Grossman and Rossi-Hansberg (2008) analyze the distributional effects that improvements in ICT have as specific tasks in the production process can be offshored more easily. Grossman and Rossi-Hansberg (2006) and Levy and Murnane (2004) underline that the routine tasks, which are more easily programmable, are also easier to offshore. Next to the fact that routine tasks are easier to explain to someone abroad they are also easier to monitor. Oldenski (2010) finds that firms relocate rather routine tasks through foreign direct investments while non-routine tasks are performed within the firm as communication is more important for these tasks.

It follows from the literature that routine tasks are more easily replaceable by a computer, they are easier to teach to workers abroad, they are more easily transferable abroad, and they are easier to monitor. While Grossman and Rossi-Hansberg (2006) and Levy and Murnane (2004) discuss the characteristic of routine tasks to be easier to monitor, they only mention improvements of monitoring possibilities through ICT over time in passing.

Schneider (2011) finds a common impact of ICT investments and economic integration as a main source for a decreasing labor share in European countries. The model by Bental and Demougin (2010) and my empirical assessment in this paper lead to an additional explanation of these trends. Not only the easier relocation of production processes through ICT, but also a reduction in rents through improvements in monitoring technology may be the cause. There may be two effects of improved monitoring technology on the labor share. In a direct effect, monitoring precision leads to a reduction in bargaining power and therefore in wages and in an indirect effect it improves the offshoring possibilities of firms as production process abroad can be more closely followed and assessed.

Future work should assess the impact of improving monitoring precision on wages for tasks in contrast to the price effect of decreasing prices on ICT. Furthermore the influence of ICT on bargaining power and their common impact on the labor share is interesting, but difficult to study. Common indicators for bargaining power are union coverage or strikes. These are very indirect measures as the bargaining power of a union may decrease while coverage is fixed. Stronger indicators for bargaining power would allow to disentangle different influences.

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Figure 2: France: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data and the dotted the simulated approximation.

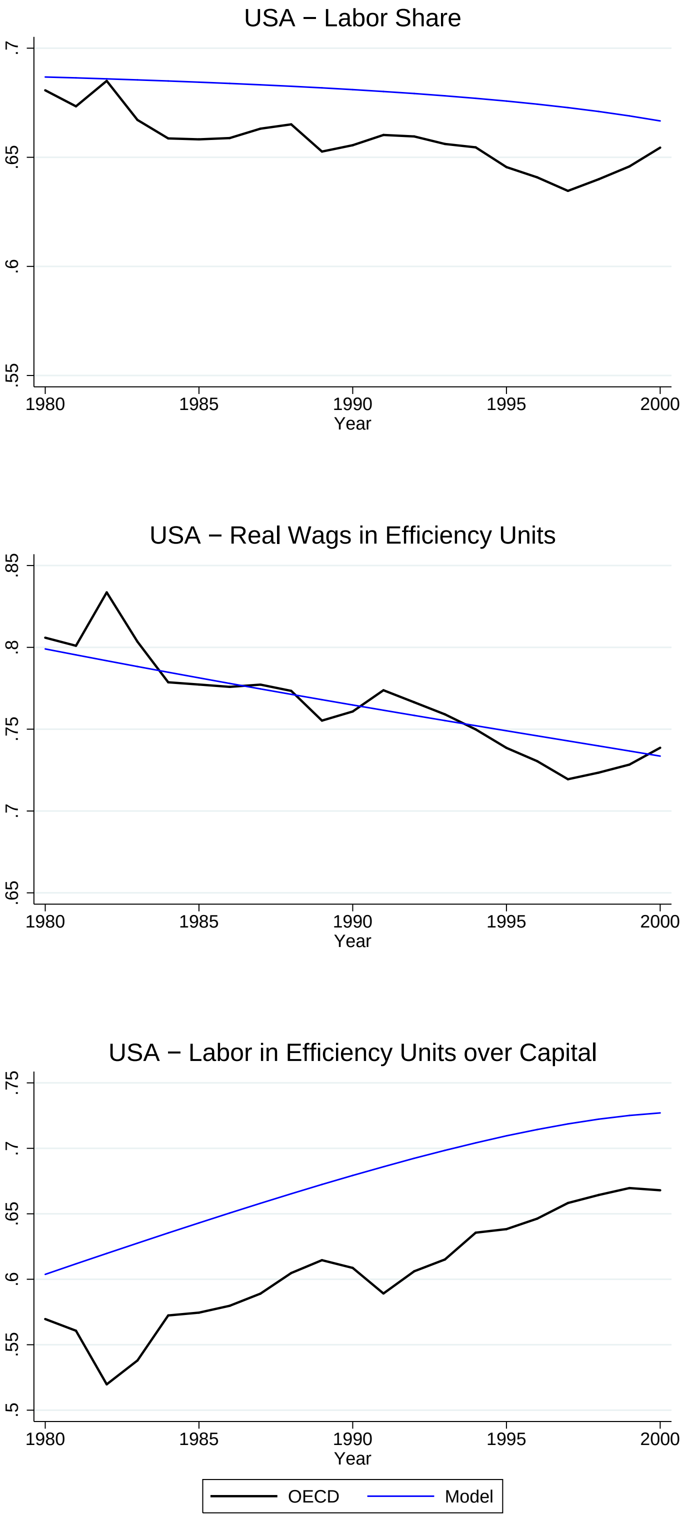

Figure 3: USA: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data and the dotted the simulated approximation.

Figure 4: Australia: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

Figure 5: Belgium: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

Figure 6: Italy: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

Figure 7: Germany: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

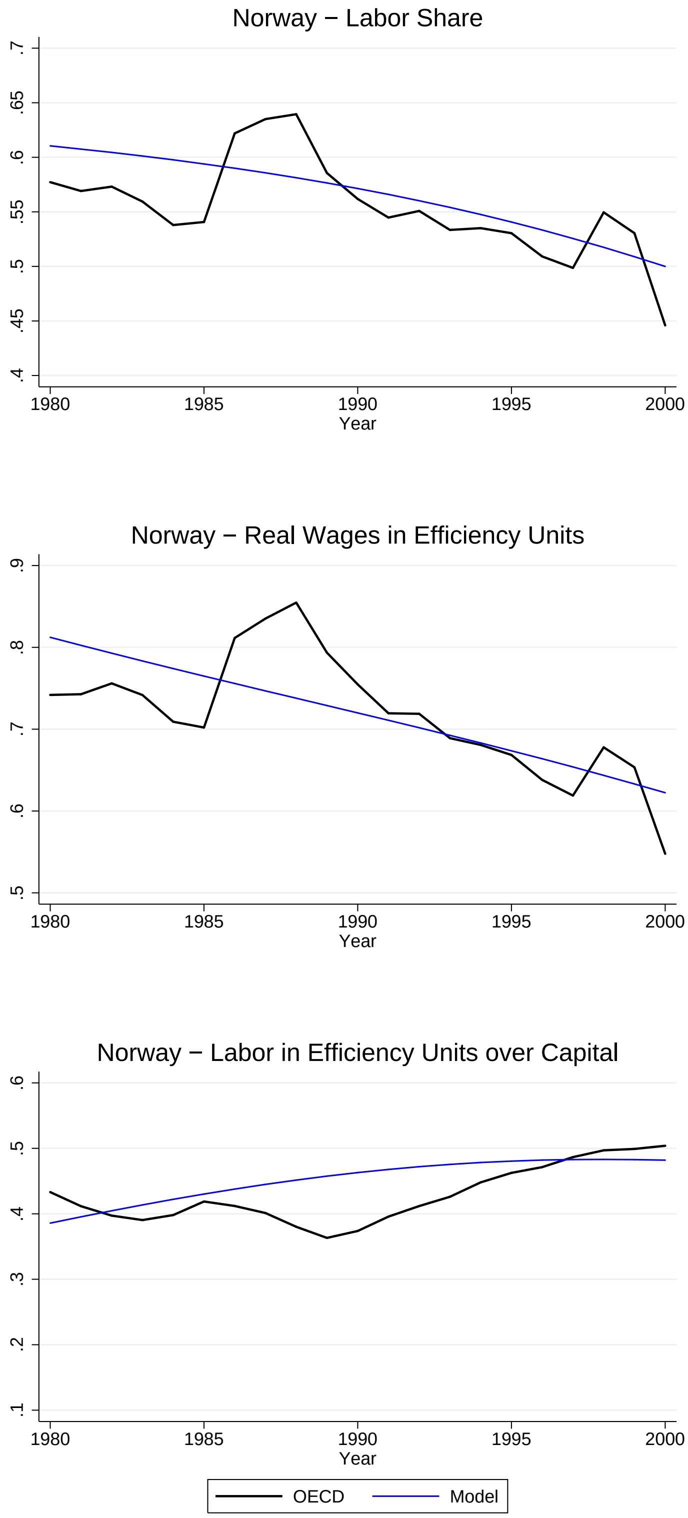

Figure 8: Norway: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

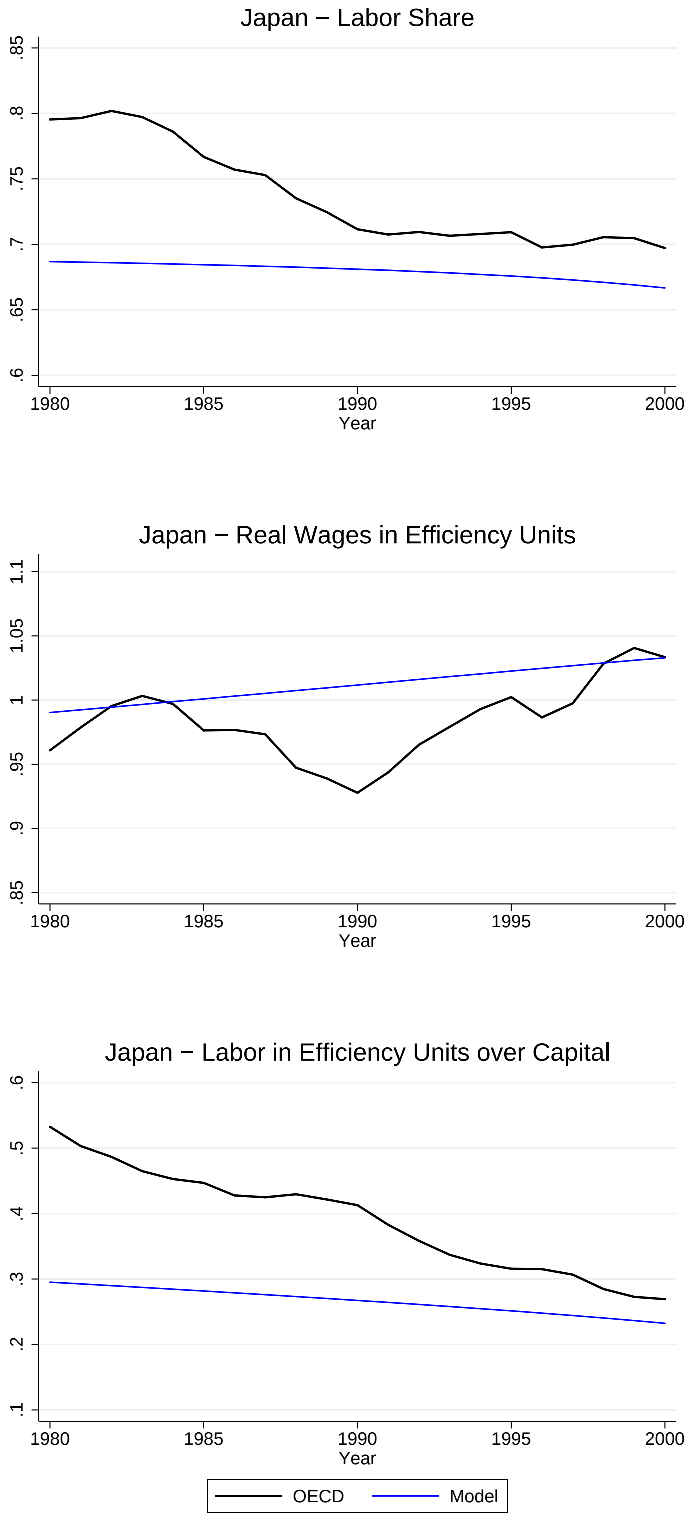

Figure 9: Japan: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

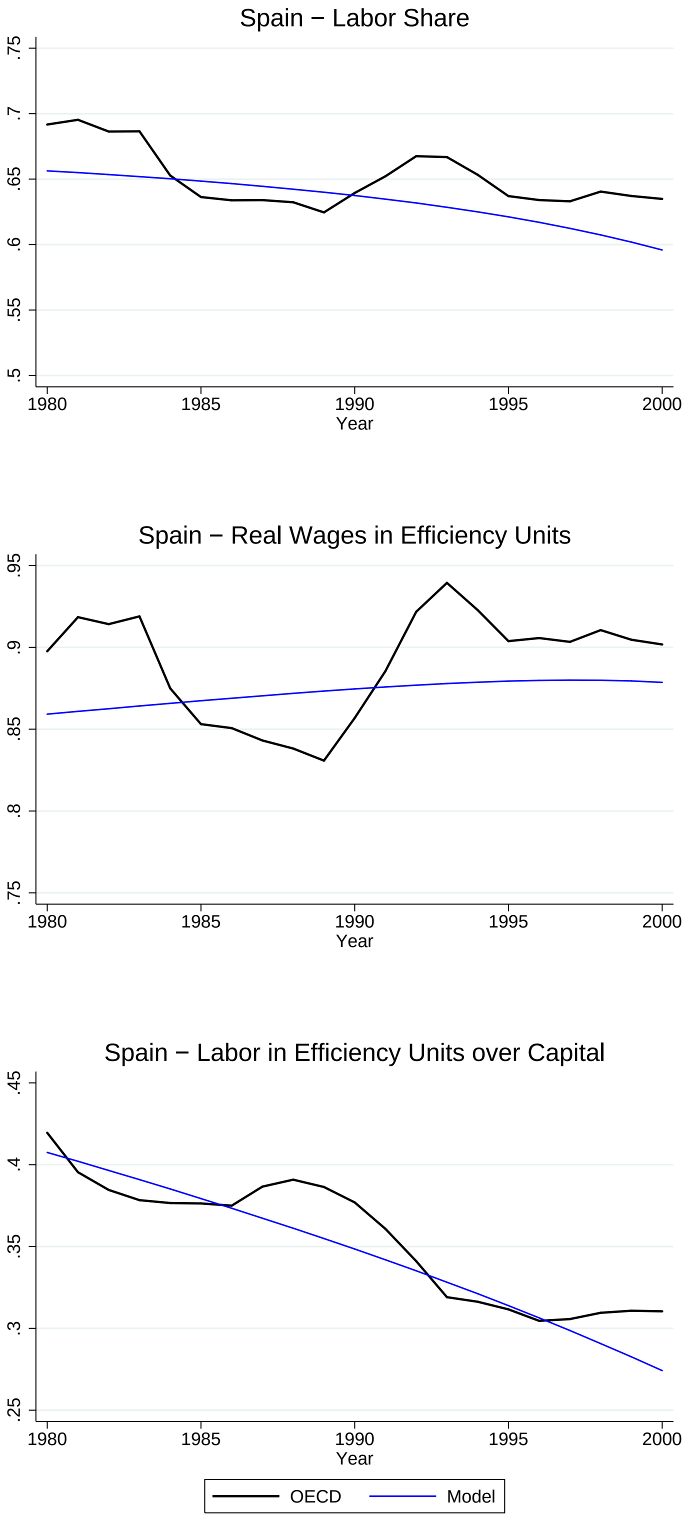

Figure 10: Spain: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

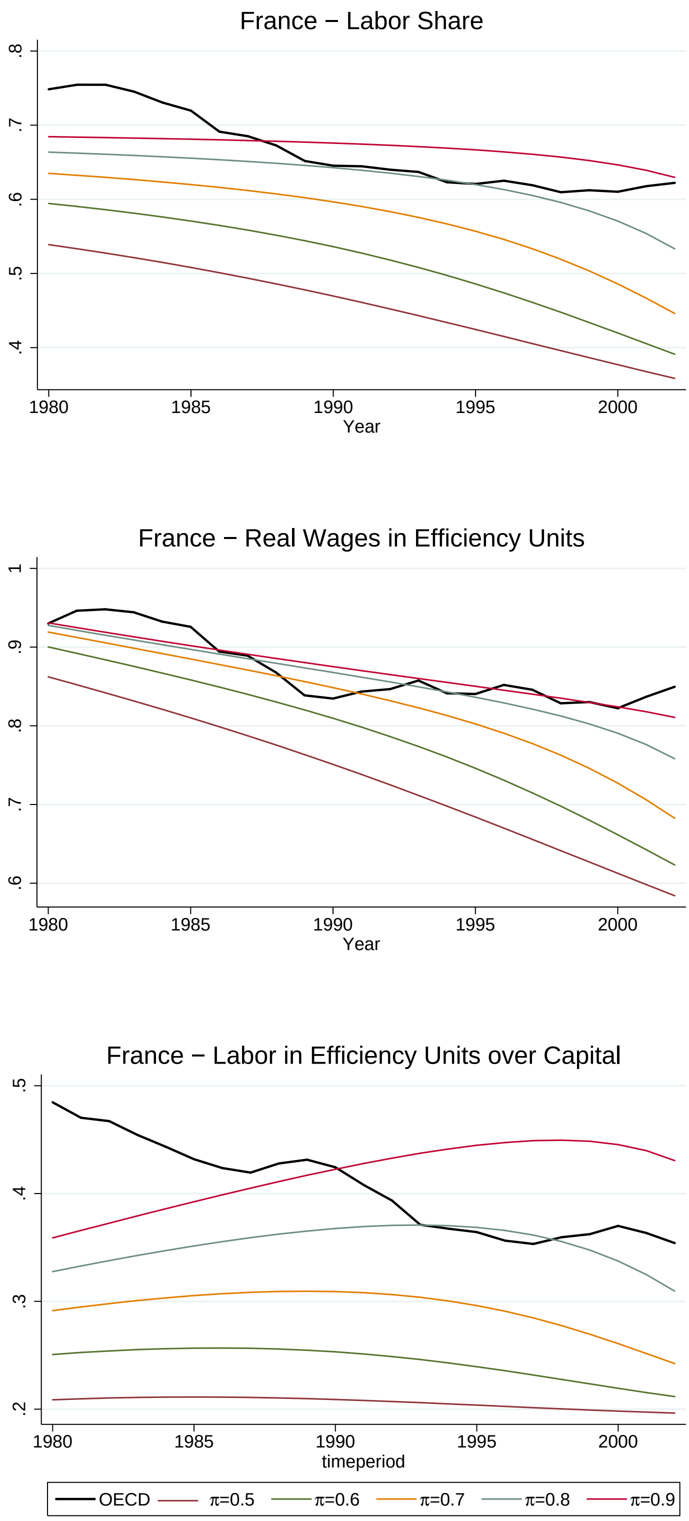

Figure 11: France: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data. The other lines show a biased social planner. The lowest dashed line shows the results for $\pi = 0.5$. Each line up shows the simulation results for $\pi = 0.6$ up to $\pi = 0.9$. The higher the worker's weight is, the higher is the simulated graph.

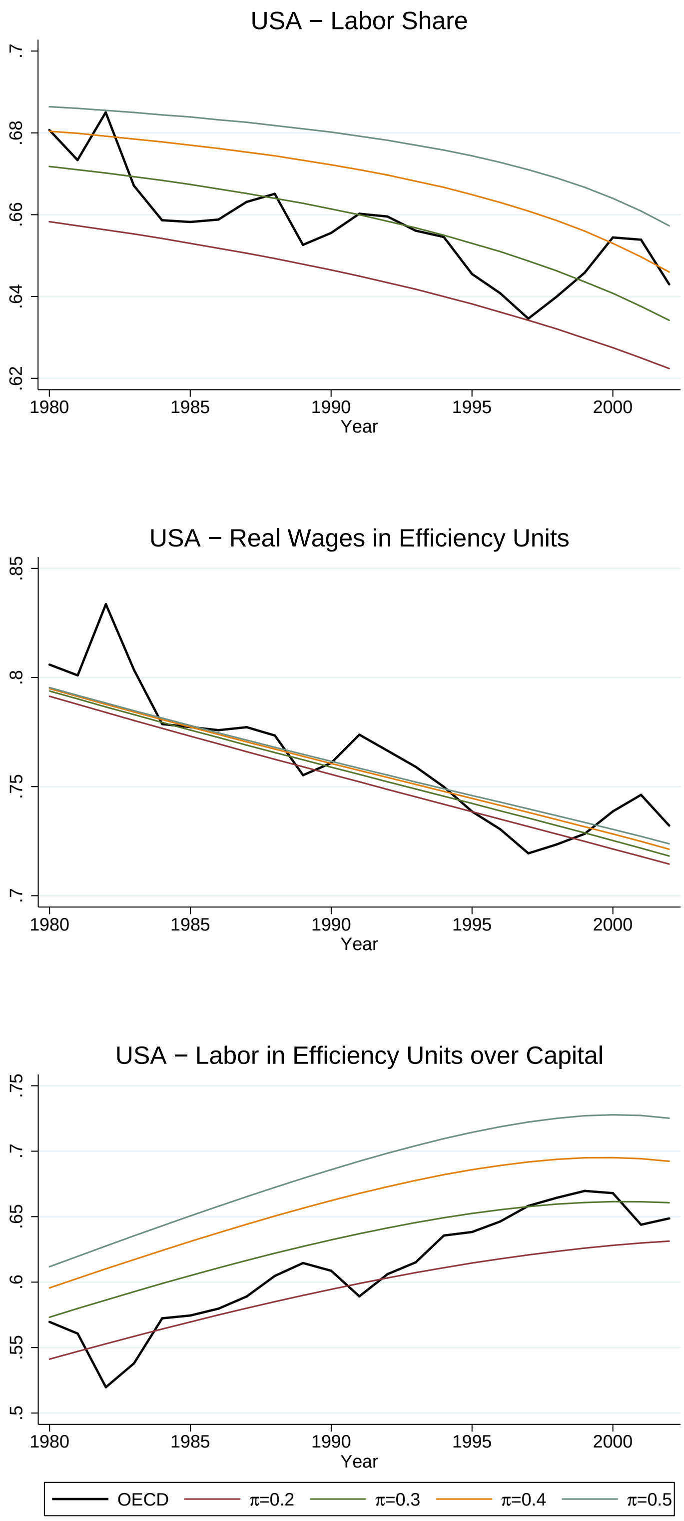

Figure 12: USA: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data. The other lines show a biased social planner. The highest dashed line shows the results for $\pi = 0.5$. Each line down shows the simulation results for $\pi = 0.4$ up to $\pi = 0.2$. The lower the worker's weight is, the lower is the simulated graph.

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